

We claim:

1. In a process for hydrogenating a feedstream in a hydroprocessing reactor, the feedstream comprising a heavy hydrocarbon liquid component and a hydrogen gas input component, the hydrogen gas input component comprising a recycle gas stream and a makeup gas stream, the reactor producing an effluent liquid stream and an effluent gas stream, the effluent gas stream comprising unreacted hydrogen and methane and heavier hydrocarbons, the improvement comprising:

- a) cooling the separated effluent gas stream to a temperature in the range of +30°F (-1.1°C) to -40°F (-40°C);
- b) contacting the cooled effluent gas stream with a lean liquid solvent stream in an absorption zone to absorb the methane and heavier hydrocarbons from the effluent gas stream to produce a hydrogen-rich gas stream containing 90 to 99 mol% hydrogen and a rich liquid solvent stream;
- c) recovering the hydrogen-rich gas stream from the absorber zone;
- d) adding the hydrogen-rich gas stream to the hydroprocessing reactor feedstream as the recycle gas stream; and
- e) flashing the rich liquid solvent stream in at least one flashing stage to produce the lean liquid solvent stream comprising C<sub>4</sub> to C<sub>5</sub> components present in the separated effluent gas stream

for contacting the cooled effluent gas stream in step (b), and to produce a methane and heavier hydrocarbon gas product stream.

2. The process of claim 1, wherein the hydroprocessing reactor is selected from the group consisting of hydrodesulfurization, hydrocracking, hydrodenitrification, hydrodealkylation and hydrotreating reactors.

3. The process of claim 2, wherein the reactor is a hydrocracking reactor operating at a pressure in the range of 500 psig (35.1 kg/cm<sup>2</sup>g) to 5,000 psig (351.5 kg/cm<sup>2</sup>g).

4. The process of claim 3, wherein the hydrocracking reactor is operating at a pressure in the range of 1,000 psig (70.3 kg/cm<sup>2</sup>g) to 3,000 psig (210.9 kg/cm<sup>2</sup>g).

5. The process of claim 2, wherein the reactor is selected from the group consisting of hydrodealkylation and hydrotreating, and the reactor is operating at a pressure in the range of 200 psig (14.1 kg/cm<sup>2</sup>g) to 3,000 psig (210.9 kg/cm<sup>2</sup>g).

6. The process of claim 2 wherein the effluent liquid product and gas streams from the reactor are passed through a high pressure separator operating at a pressure in the range of 200 psig (14.1 kg/cm<sup>2</sup>g) to 5,000 psig (351.5 kg/cm<sup>2</sup>g).

7. The process of claim 2, wherein the effluent gas stream and lean liquid solvent stream are contacted in an absorber zone at a pressure in the range of 200 psig (14.1 kg/cm<sup>2</sup>g) to 5,000 psig (351.5 kg/cm<sup>2</sup>g).
8. The process of claim 7, wherein the effluent gas stream and lean liquid solvent stream are contacted in an absorber zone at a pressure in the range of 200 psig (14.1 kg/cm<sup>2</sup>g) to 3,000 psig (210.9 kg/cm<sup>2</sup>g).
9. The process of claim 1, wherein the hydrogen gas input component of the reactor feed stream contains 90-99 mol% hydrogen.
10. The process of claim 2, wherein the heavy hydrocarbon liquid component feed contains sulfur, and the methane and heavier hydrocarbon gas product stream obtained in step (e) contains hydrogen sulfide, the process including the further steps following step (e) of:
  - 5 f) contacting the methane and heavier hydrocarbon gas product with a lean amine solution in a treatment zone for removing the hydrogen sulfide and thereby providing a sweetened methane and heavier hydrocarbon gas product;
  - 10 g) recovering the H<sub>2</sub>S-rich amine solution from the treatment zone; and
  - h) passing the H<sub>2</sub>S-rich amine solution through a regeneration column for producing a lean amine solution for contacting in

step (f).

11. The process of claim 1, wherein the separated effluent gas stream is chilled to a temperature between 0°F (-17.9°C) and -20°F (-28.9°C).

12. The process of claim 11, wherein the effluent gas stream is cooled to a temperature in the range of -10°F (-23.3°C) to -15°F (-26.1°C).

13. The process of claims 1 or 11, wherein the separated effluent gas stream contains water and the separated effluent gas stream is co-chilled with ethylene glycol and the ethylene glycol/water mixture is separated from the chilled hydrocarbon gas and hydrocarbon liquid streams prior to entering the absorber.

14. The process of claim 1, wherein the heavy hydrocarbon component is selected from the group consisting of naphtha, kerosene, diesel, light vacuum gas oil, heavy vacuum gas oil, demetalized oil, coker gas oil, resid, fuel oil and aromatics.

15. The process of claim 1, wherein the makeup gas stream contains 70 to 99 mol% hydrogen.

16. The process of claim 1, wherein the recovered hydrogen-rich gas stream from an absorption zone is further cross heat exchanged with the reactor effluent gas stream.

17. The process of claim 1, wherein the cooled effluent gas stream is contacted in step (b) with the lean liquid solvent stream in counter-current flow.
18. The process of claim 1, wherein the lean liquid solvent stream enters the absorption zone at a temperature in the range of +30°F (-1.1°C) to -40°F (-40°C).
19. The process of claim 18, wherein the lean liquid solvent stream enters the absorption zone at a temperature in the range of 0°F (-17.8°C) to -20°F (-28.9°C).
20. The process of claim 19, wherein the lean liquid solvent stream enters the absorption zone at a temperature in the range of -10°F (-23.3°C) to -15°F (-26.1°C).
21. The process of claim 1, wherein the rich liquid solvent stream passes through at least two successive flash separators.
22. The process of claim 21, wherein the separated gases from the first successive flash separator are compressed and returned to the absorption zone of step (b).
23. The process of claim 21, wherein flash separators are gas-liquid 2-phase separation drum.
24. The process of claim 21, wherein the successive flash separators operate at successively lower pressure than the operating pressure in the absorption zone.
25. The process of claim 2, wherein the heavy hydrocarbon liquid

component feed contains sulfur, and the separated effluent gas stream comprising unreacted hydrogen and methane and heavier hydrocarbons contains hydrogen sulfide, the process including the further steps of:

- (i) contacting the separated effluent gas stream with a lean amine solution in a treatment zone for removing the hydrogen sulfide and thereby providing a sweetened hydrogen and methane and heavier hydrocarbons gas stream for cooling in step (a);
- (j) recovering the H<sub>2</sub>S-rich amine solution from the treatment zone; and
- (k) passing the H<sub>2</sub>S-rich amine solution through a regeneration column for producing a lean amine solution for contacting in step (i).

26. The process of Claim 6, wherein the separated liquid product from the high pressure separator is let down in pressure to produce a low pressure liquid and gas stream.

27. The process of Claim 26, wherein the low pressure liquid and gas stream are separated in a low pressure separator to produce a low pressure hydrogen-rich gas stream.

28. The process of Claim 27, wherein the low pressure hydrogen-rich gas stream is:

- (i) compressed and chilled prior to entering the absorption zone of step (b) of Claim 1 for co-processing; or

(ii) chilled and contacted with a lean solvent stream comprised of C<sub>4</sub> to C<sub>5</sub> components present in the reactor effluent gas stream to produce a low pressure high-purity hydrogen recycle stream containing 90 to 99 mol% hydrogen.

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